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Wear Characteristics of B_4C and Al_2O_3 Reinforced with Al 5083 Metal Matrix based Hybrid Composite

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Abstract

Present work deals with the investigation of the wear behavior of Al 5083 composites synthesized by stir casting technique reinforced with constant weight percentage (5%) of Al_2O_3 and four different weight percentages of B_4C (0%, 3%, 5%, and 7%)were taken for investigation. Evaluation of wear properties with the different reinforcement has been obtained. Wear test carried out by the pin-on-disc method under dry conditions with the different load 10, 20N. The worn surface was investigated by the Scanning Electron Microscope (SEM). The investigation reveals that the wear resistance has been improved by increasing weight percentage of B_4C and Al_2O_3, the worn samples show a light adhesive wear traces at the same condition.

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Keywords: Stir casting; Al_2O_3; B_4C; Al 5083.

1. Introduction

The composite materials are plays a vital role in the modern technology. Aluminium matrix composite (AMC) are an important material in the industrial world. AMC has good mechanical properties it is widely used in aerospace, automobile, marine [1-3].When it is reinforced with the hard ceramic particles like B_4C, $ZrSiO_4$ resulting in increased wear resistance and mechanical strength. Ceramic reinforced Al alloys are widely used because of their excellent wear resistance and low density in automobile industries [7].In addition, Al-Al_2O_3 composites having good mechanical and tribological properties are used at crank bearings and motor blocks in order to improve wear resistance [8, 9], According to the type of reinforcement the aluminium matrix are manufactured by different methods such as stir casting, squeeze casting and powder metallurgy.

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As compared with other process, stir casting is most common method and also low cost processing method for producing AMC matrix. Stir casting offers better matrix particle bonding because of stirring action of particles in to the metals. The recent research studies reported that the homogenous mixing and good wetting can be obtained by selecting appropriate processing parameters like stirring speed, time, temperature of molten metal, preheating temperature of the mould and uniform feed rate of particles [6].

2. Experimental procedure

In order to process the specimen, the chemical composition of an Al 5083, have shown in the Table 1.The reinforcement particles were Al_2O_3 with the Nano particles and B_4C with the mesh size of 400μ.The materials have been weighed with the volume of the fraction shown in Table 2. After weighting each of the material a batch of 3000g of Al alloy melted at 800℃ using an Electrical Resistance Furnace.

Table 1 Chemical composition of Al5083

ELEMENT	Al	Mn	Cu	SiC	Zn	Ti	Cr	Mg	Fe
PERCENTAGECOMPOSITION (%)	92.7	4.0-4.9	0.4-1.0	0.4	0.25	0.05-0.25	0.05-0.25	0.15	0.1

The metal was organized with the help of a mechanical stirrer to form a vortex. The process parameter is shown in Table 3.The mixture of preheated B_4C and Al_2O_3 were added constant feed rate into the vortex the process parameter employed give in the Table 3.

Table 2 Volume of fraction

SAMPLE	**Al 5083 in (gms)**	**Al_2O_3in (gms)**	**B_4C in (gms)**	**% of the composition**
1	3000	0	0	0%
2	2910	150	90	8%
3	2850	150	150	10%
4	2790	150	210	13%

During experimental work, the reinforcement was added slowly to obtain a better dispersion. The mould box was preheated at 500°C.The additives added were Degas tablet and Skum powder. The Degas tablet is used to prevent the oxidation of Al 5083 and skum powder is used to remove the slag or flux. After stirring the molten mixture was poured into cast permanent mould (220×150×30mm). Then the AMCs have the constant weight percentage (5%) of Al_2O_3 and varying the percentage of B_4C (3%, 5% and 7%).The entire specimen was cooled in cast mould box at room temperature. The solidified components a Scanning Electron Microscope (SEM) was stocked away to examine the distribution of reinforcement in Al matrix. Wear test was carried out on pin-on-disc wear testing. The unit consists of a gimballed arm to which the pin is attached. Evaluate the wear behavior of the alloy, against the hardened ground steel disc (EN-32) Hardness (62HRC) Speed Range 0-1000 RPM, Track Diameter 50 mm-180 mm, Load is applied at pin by dead weight centred.

Table 3 Process parameters of stir casting

Parameters	Value
Melting temperature	800 ^{o}C
Stirring temperature	785-795 ^{o}C
Stirrer speed	640 rpm
Stirring time after reinforcement	20 minutes
Incubation time	3 hours

Weight loss of the all samples was determined as a function of sliding distance and loads. The surface of the samples was cleaned with the acetone solution before wear test. The test was carried out with different velocity (1, 1.5,2 m/s), and load condition (10, 20 N) was determined. The worn surface of the samples was investigated by using Scanning Electron Microscope (SEM).

3. Results and Discussion

The microstructure of Al-Al_2O_3-B_4C hybrid composite specimens revealed the presence of Al_2O_3-B_4C particles in Al 5083, the Al_2O_3-B_4C particles adhere well to the Al matrix is read, it is socked with the Al Matrix in Stir casting process, Wear test sample is prepared as per ASTM standard [10].Typical plots of wear rate versus time and wear loss of different reinforcement as shown for a load of 10Nand 20 N This result shows the 0% Al has the wear rate is high, compared to the hybrid composite after for 30 minutes duration. The graph plot also shows that 12% have close related wear value .

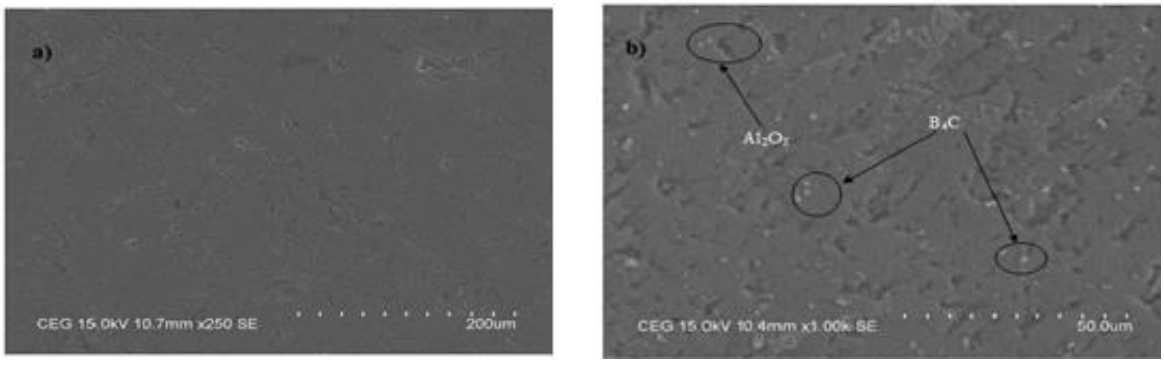

Fig. 1.SEM photomicrographs of the cast Al5083-Al_2O_3-B_4C AMCs: a) 0% b) 8%

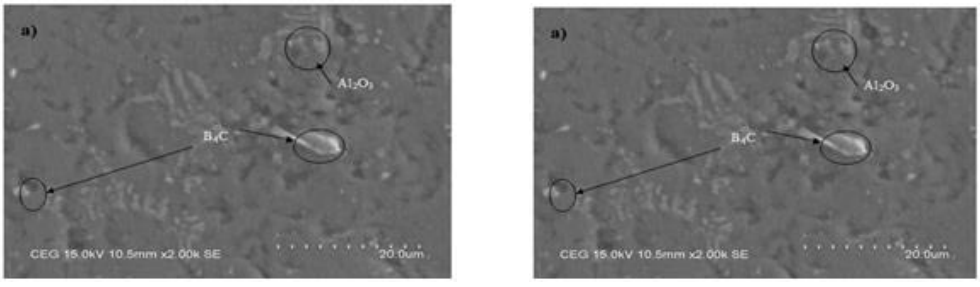

Fig. 2.SEM photomicrographs of the cast Al5083-Al_2O_3-B_4C AMCs: a) 10% b) 12%

The 8% hybrid composite has better wear resistance at the goal of 30 minute's duration. The wear rate decreases due to presents of Al_2O_3 and B_4C in MMC. From the wear graph it is intelligible that the wear rate is minimized in the hybrid reinforced composite while comparing to the singular reinforced composite combinations, when determining the comparative chart among all composite combinations at all varying speed. The wear resistance increases in addition of Al_2O_3 and B_4C up to 8%, 10%, and 12%

The specimen was carried dry adhesive wear, the worn surface is observed under Scanning Electron Microscope (SEM) to investigate the wear mechanism, the micrographs of the worn surface taken in high magnification. The investigation about the SEM image indicates that Al 0% has surface fit and continuous wear occurs, the sliding direction also included in the SEM image. The weight loss of Al 0% is high at the conclusion of the 30 minutes duration. For the 10N, the wear rate of Al 0% increase when the load increases. The surface of Al 5083 alloy shows the least amount of surface fit.

The wear of the Al0% by sample is constant wear occurs over the tested area. However, the micro cracks format at the sharpness of the open. For Al- Al_2O_3 -B_4C 8% large range of surface fit was occurring. The wear rate of the sample surface is not equal. Referable to the presence of Al_2O_3 and B_4C particles the wear resistance is high the MMC acts as a resistance of the fabric to wear. The sample has the abrasive groove on one end of the surface, which is slightly formed in the way of wear. Compared to Al 0% the Al-Al_2O_3 -B_4C 8% have no micro cracks are occurring in the investigation of the surface. The plastic deformation takes place in it clearly seemed not to be abraded as much as others. The size of the surface fit is also high in Al- Al_2O_3 -B_4C 8%.

For Al_2O_3 -B_4C 10% presence acts as an excellent wear resistance. The surface fit is also less compared to Al_2O_3 -B_4C 8%. However, the irregular line is formed in the surface. This is mentioned thus the MMC plays the role in the Al5083, which have less wear surface. However, in the investigation, there are no micro cracks formed in it. The surface of the Al_2O_3 /B_4C 10% has no uniform wear. Investigation of the surface also indicates significant surface fit is occurring in one of the corner portion which has a high material loss.

For Al_2O_3 -B_4C 12% the surface of the sample is slightly different, one side groove is formed and another side the surface fit is highly formed in the surface. The irregular flow lines are in the same direction of the sliding shows the worn surface roughness after wear test.

The specific wear rate for composites decreases gradually with increasing amount of Al_2O_3 -B_4C, sliding velocity and average load, at a greater load, and higher speed specific wear rate decreases with increases in Al_2O_3 -B_4C percentage content. Wear co-efficient tends to decrease with increasing particle volume content. It also indicates that Al_2O_3 -B_4C percentage addition is beneficial in reducing the wear of the Al 5083 composites.

4. Conclusion

The following conclusions may be drawn from the study: -

i. The samples are successfully fabricated with the stir casting process.
ii. Wear loss of particle reinforced Al specimens decreased due to presents of Al_2O_3 -B_4C the fracture particle during the wear is mostly embedded in the Al matrix.
iii. The microstructure SEM shows the particular distribution was found to be better in Al-Al_2O_3-B_4C; Al composite seemed to exhibit a better interfacial bonding.
iv. The wear resistance of Al_2O_3 -B_4C 8% has excellent wear resistance due to the presents of Al_2O_3-B_4C.
v. The wear rate of Al_2O_3 -B_4C 8% was approximately 10% lower than the other Al_2O_3 -B_4C 10%, Al_2O_3 -B_4C 12%.

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